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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,740	11/13/2003	In Kyu Chun	20059/PIA30957	8888
34431	7590	03/27/2006	EXAMINER	
HANLEY, FLIGHT & ZIMMERMAN, LLC 20 N. WACKER DRIVE SUITE 4220 CHICAGO, IL 60606			MALSAWMA, LALRINFAMKIM HMAR	
			ART UNIT	PAPER NUMBER
			2823	

DATE MAILED: 03/27/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

A

<b>Office Action Summary</b>	Application No. 10/712,740	Applicant(s) CHUN, IN KYU	
	Examiner Lex Malsawma	Art Unit 2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 27 December 2005.
- 2a) ☒ This action is **FINAL**.                      2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-4 and 7-11 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-4 and 7-11 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 13 November 2003 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All    b) ☐ Some \*    c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)  | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)                                   | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152)             |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)<br>Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____  |

## DETAILED ACTION

### *Claim Rejections - 35 USC § 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claim 1 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Modak** (6,537,913 B2) in view of **Liu** (6,211,085 B1).

#### *Regarding claim 1:*

Modak discloses a method of forming a Cu line in semiconductor fabrication, comprising:

forming a dual damascene pattern (Fig. 1a) by etching a PMD 101 layer formed on a substrate 100, wherein the dual damascene pattern includes a contact hole portion 103 located on the substrate and a trench portion 104 located on the contact hole portion, the width of the contact hole portion being narrower than that of the trench portion;

depositing a "first" diffusion barrier 106 (Fig. 1b and Col. 3, lines 4-6) on sidewalls of the dual damascene pattern;

filling the dual damascene pattern with "a first metal" 105 (copper) by depositing the first metal on the first diffusion barrier to form a first metal layer;

chemical mechanical polishing a portion of the first metal layer 105 over the trench portion (Col. 3, lines 23-26);

etching the upper part of the first metal layer in the trench portion so as to not expose a void in the contact hole, thereby forming a first-metal plug 111 (Fig. 1c and Col. 4, lines 10-14) that occupies a lower part of the first metal layer in the trench portion and the contact hole portion (Fig. 1c, note that the etching is performed only in the upper part of the trench portion and the etching does not reach the contact-hole portion, therefore no void is exposed in the contact-hole portion of the dual-damascene pattern);

depositing a second diffusion barrier 107 on the first-metal plug 111 (Fig. 1d);  
depositing a second metal 108 on the second metal diffusion barrier 107 (Fig. 1d); and removing a portion of the second metal 108 outside of the trench by a chemical mechanical polishing (CMP) process (note Figs. 1d-1e and Col. 4, lines 41-47).

Modak **lacks** the “first metal layer 105” being tungsten and the “second metal layer 108” being copper. However, it is important to note that Modak discloses the essential process steps/sequence of the current claim; and the only essential difference between the Modak and the current invention seems to be in preferred materials for the first and second metal layers.

*Furthermore, it is important to note that Modak specifically discloses (in Col. 5, lines 22-29), “[a]lthough the foregoing description has specified certain...materials..., those skilled in the art will appreciate that many modifications and substitutions may be made”.* Liu is **cited primarily to show** it was very well known in the art that a dual-damascene-contact structure may be formed by specifically incorporating tungsten (i.e., wolfram 80) and copper 94 (note Figs. 4-6 and Col. 4, lines 44-62), wherein tungsten is used in a contact hole portion (i.e., used as a first metal layer) and copper is used to fill a trench portion of the dual-damascene-contact structure (i.e., the copper is used as a second metal layer).

In sum, Modak discloses the essential process steps of the claimed invention and specifies that many substitutions may be made at least for the materials specified in the disclosure. Liu shows that the specific materials (W and Cu) recited in the claimed invention are well known to be suited for a dual-damascene-contact structure. Accordingly, it would have been obvious to one of ordinary skill in the art to modify Modak by specifically utilizing materials such as W and Cu because Liu shows that such materials are well-known to be suited for a dual-damascene-contact structure, and it has been held to be within the general skill of a worker in the art to select a known material on the basis of its suitability for the intended use as a matter obvious design choice. *In re Leshin*, 125 USPQ 416. Furthermore, when Modak is modified by specifically utilizing W and Cu as shown by Liu, the portions of the Cu outside of the trench would be removed by CMP because Modak specifically discloses the second metal 108 is removed by CMP (Col. 4, lines 41-47). When the second metal "108" is replaced with Cu, then the CMP process for removing the Cu would obviously be referred to as a Cu CMP process.

3. Claims 2-4 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Modak** (in view of **Liu**) as applied to claim 1 above, and further in view of Huang et al. (5,527,736; hereinafter, "**Huang**").

*Regarding claim 2:*

Modak (in view of Liu) **lacks** performing dry-etching process on the first metal layer 105; however, it is noted that Modak specifies a wet-etching process is used primarily because the first metal layer is specifically copper (Col. 4, lines 10-14). Huang **teaches** that it is

conventional in the art to utilize dry etching when forming a recessed tungsten plug 24 within a contact hole (note Figs. 2, 5, Col. 1, lines 31-33; and Col. 2, lines 57-60). Given that Modak (in view of Liu) incorporates a tungsten layer to provide a tungsten plug, it would have been obvious to one of ordinary skill in the art to specify a dry-etching process performed on the tungsten layer (of Modak in view of Liu) because Huang teaches that it was conventional in the art to etch tungsten by dry etching.

*Regarding claims 3 and 4:*

Modak discloses the first diffusion barrier 106 includes titanium nitride and the second diffusion barrier layer 107 includes tantalum nitride (Col. 3, lines 4-6 and Col. 4, lines 25-28); and Liu also discloses that a suitable diffusion barrier 90 includes Ta, TaN or TiN (Figs. 5-6 and Col. 4, lines 53-55).

4. Claims 7 and 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over **Modak** (in view of **Liu** and **Huang**) as applied to claim 4 above, and further in view of Chou et al. (US 2004/0005775 A1; hereinafter, "**Chou**").

*Regarding claims 7 and 8:*

Modak (in view of Liu and Huang) lacks the tungsten diffusion barrier layer being a Ti/TiN double layer. Chou teaches that a Ti/TiN double layer provides both adhesion and barrier protection for a tungsten layer formed with a via opening (note section 0033); and in section 0029, Chou teaches that a range in thickness for the double layer is about 2nm to 50nm for the Ti layer and about 2nm to 50nm for the TiN layer. I would have been obvious to one of ordinary skill in the art to modify Modak (in view of Liu and Huang) by replacing the diffusion

layer with an adhesive/diffusion double layer, as taught by Chou, because the modification would provide an adhesive layer in addition to a diffusion barrier for the tungsten "plug".

5. Claims 9-11 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Modak** (in view of **Liu, Huang and Chou**) as applied to claim 8 above, and further in view of Yang et al. (6,734,559 B1; hereinafter, "**Yang**") and **Yuang** (US 2003/0139034 A1).

*Regarding claims 9-11:*

Yang and Yuang are cited to show it would have been obvious to replace the single diffusion layer (in Modak and/or Liu) with a double layer comprising Ta/TaN. In a manner similar to that taught by Chou, Yang teaches, for copper interconnects, it is useful to utilize a double layer (instead of a single layer) such as Ta/TaN because the double layer provides both adhesion and barrier protection for the copper (see Yang, Col. 2, lines 39-44). However, since Yang does not specify thickness ranges for Ta and TaN within a double-layer structure, Yuang is cited to show well known ranges for a Ta/TaN double layer. Yuang discloses (in section 0022), when a Ta/TaN double layer is formed as an adhesion/barrier layer for copper, the Ta layer is generally 1 to 20 nm thick, and the TaN layer is approximately 1 to 100nm.

It would have been obvious to one of ordinary skill in the art to further modify Modak (in view of Lin, Huang and Chou) by replacing the single Cu barrier layer with a double layer comprising Ta/TaN, as taught by Yang and Yuang, because the modification would provide an adhesive layer in addition to a diffusion barrier for the copper. Lastly, the thickness range(s) disclosed by the references (Chou and Yuang) are such that one of ordinary skill in the art could

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have easily formed the Ti/TiN double layer to be thicker or thinner than the Ta/TaN double layer; therefore, claim 11 is deemed obvious over the cited references.

### *Remarks*

6. Applicant's remarks/arguments have been carefully reviewed and considered but they are not persuasive. In general, the applicant asserts that Modak teaches away from using copper for the upper layer and there is no suggestion in the prior art for the desirability of modifying Modak to use tungsten and copper. The examiner disagrees with the applicant's assertion because Modak specifies other materials may be substituted for the materials specifically disclosed in the exemplary embodiment (see Col. 5, lines 22-29). Modak discloses that copper "within the dual-damascene hole" may oxidize; however, Modak does not teach away from using copper in the upper portion of a dual damascene trench, especially when a tungsten plug is used to fill the hole prior to depositing a copper layer in the upper portion. Liu (US 6,211,085) clearly shows copper being successfully formed in the upper portion of a dual damascene opening. It is obvious Modak has specifically selected aluminum as a capping layer in the case when copper is used to fill the lower portion of a dual damascene opening; however, this choice in combination of materials does not teach away from choosing a combination of materials such as the combination of tungsten and copper shown/taught by Liu. In other words, Modak specifically indicates that various material substitutions are possible; and given that Liu clearly shows that a combination of tungsten and copper will successfully provide a dual-damascene contact, where the combination allows copper interconnects to be formed on a first level of metallization (e.g., note Liu's abstract), one of ordinary skill in the art would have had ample motivation to modify



Modak as taught by Liu, and one of ordinary skill in the art would have had a reasonable expectation for success, especially because Liu shows the combination of materials can be successfully incorporated into a dual-damascene contact. Therefore, all pending claims currently stand rejected.

### ***Conclusion***

7. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a).

Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Lex Malsawma whose telephone number is 571-272-1903. The examiner can normally be reached on Mon. - Thur. (4-12 hours between 5:30AM and 10 PM).

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Smith can be reached on 571-272-1907. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Lex Malsawma

March 20, 2006



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SUPERVISORY PATENT EXAMINER  
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